

# Medical Entomology:

## Vectors of Disease, Bites, Stings, and Direct Injuries

**WRAIR- GEIS 'Operational Clinical Infectious Disease' Course**

**WRAIR**

Walter Reed Army  
Institute of Research

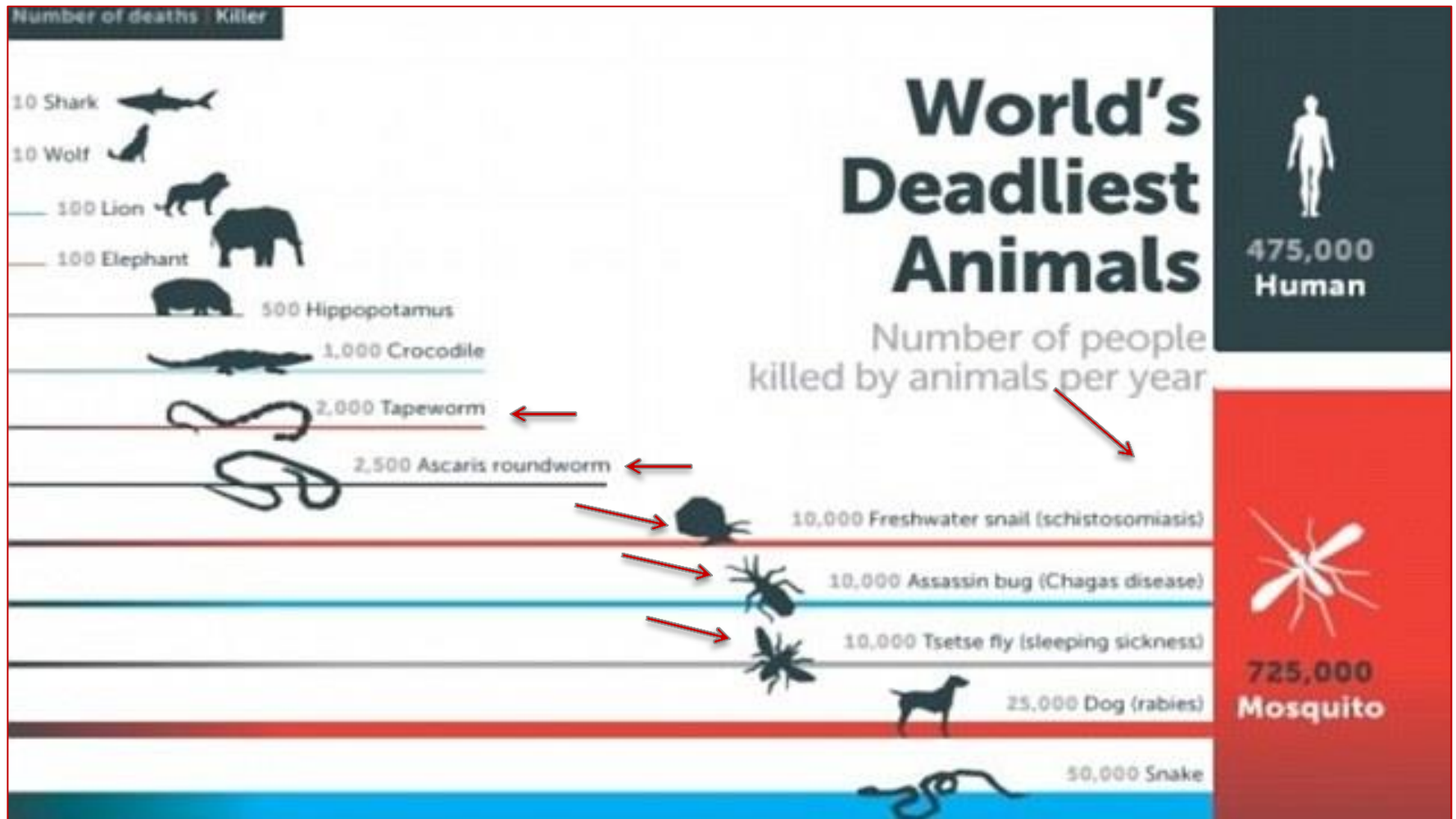
Soldier Health • World Health



# Vector Borne Disease Key Facts

- Account for 17% of all infectious diseases and cause 1M deaths annually.
- There are more than 1 billion cases and over 1 million deaths from vector-borne diseases such as:
  - 2.5B people are at risk of contracting dengue annually
  - 600K people die of malaria annually
  - Schistosomiasis, African trypanosomiasis, Leishmaniasis, Chagas disease, Yellow fever affect millions around the world.
- Distribution of these diseases are determined by a complex dynamic of environmental and social factors.

# World's Deadliest Animals



# Agenda

- What is a “Vector”
  - Types of transmission
  - Vectors and Disease
- Physical Threat
  - Bites and Stings
  - Direct Injuries
- Understanding the Threat
- Prevention
- Resources

# What is a “Vector”

- A “vector” can refer to many things depending on what context it is being used.
- In entomology the term Vector “means an arthropod that transmits a pathogen.”
- There are two types of Vectors:
  - Mechanical – vector physically moves the pathogen without it reproducing (examples: filth flies and cockroaches)
  - Biological – the pathogen replicates in the vector (examples: Mosquitoes, sand flies, ticks, fleas, biting flies, lice, etc...)

# Vector Potential

- The potential for a specific vector under certain circumstances to transmit a specific pathogen.
  - Not every arthropod can transmit a pathogen.
  - Some arthropods can transmit one type of pathogen but not another.
  - Many arthropods do not transmit any pathogens regardless of the circumstances.

# Types of Biological Transmission

- Inoculation
- Regurgitation
- Fecal contamination
- Contamination from the crushing vector

# Vectors and Diseases

Vector	Disease
Aedes spp	Dengue fever, Rift Valley fever, Yellow fever, Chikungunya, Zika
Anopheles spp	Malaria
Culex spp	Japanese encephalitis, Lymphatic filariasis, West Nile fever
Sand Flies	Leishmaniasis, Sandfly fever
Ticks	CCHF, TBE, Lyme disease, Relapsing fever, Spotted Fever, Q fever, Rocky Mountain Spotted Fever, Tularemia, Ehrlichiosis
Triatomine	Chagas Disease
Fleas	Plague
Black flies	River blindness (Onchocerciasis)
Aquatic snails	Schistosomiasis



# Components of Transmission

## ❑ Pathogen

- Where does it normally occur?      Animal host (Enzootic)? In this region (Endemic)?

## ❑ Vector (Intrinsic)

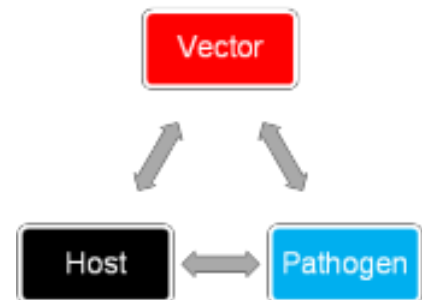
- Feeding behavior, host preference, habitat, vector competence, density, life span

## ❑ Host and reservoir populations

- Susceptibility, immunity, density, living conditions, movement

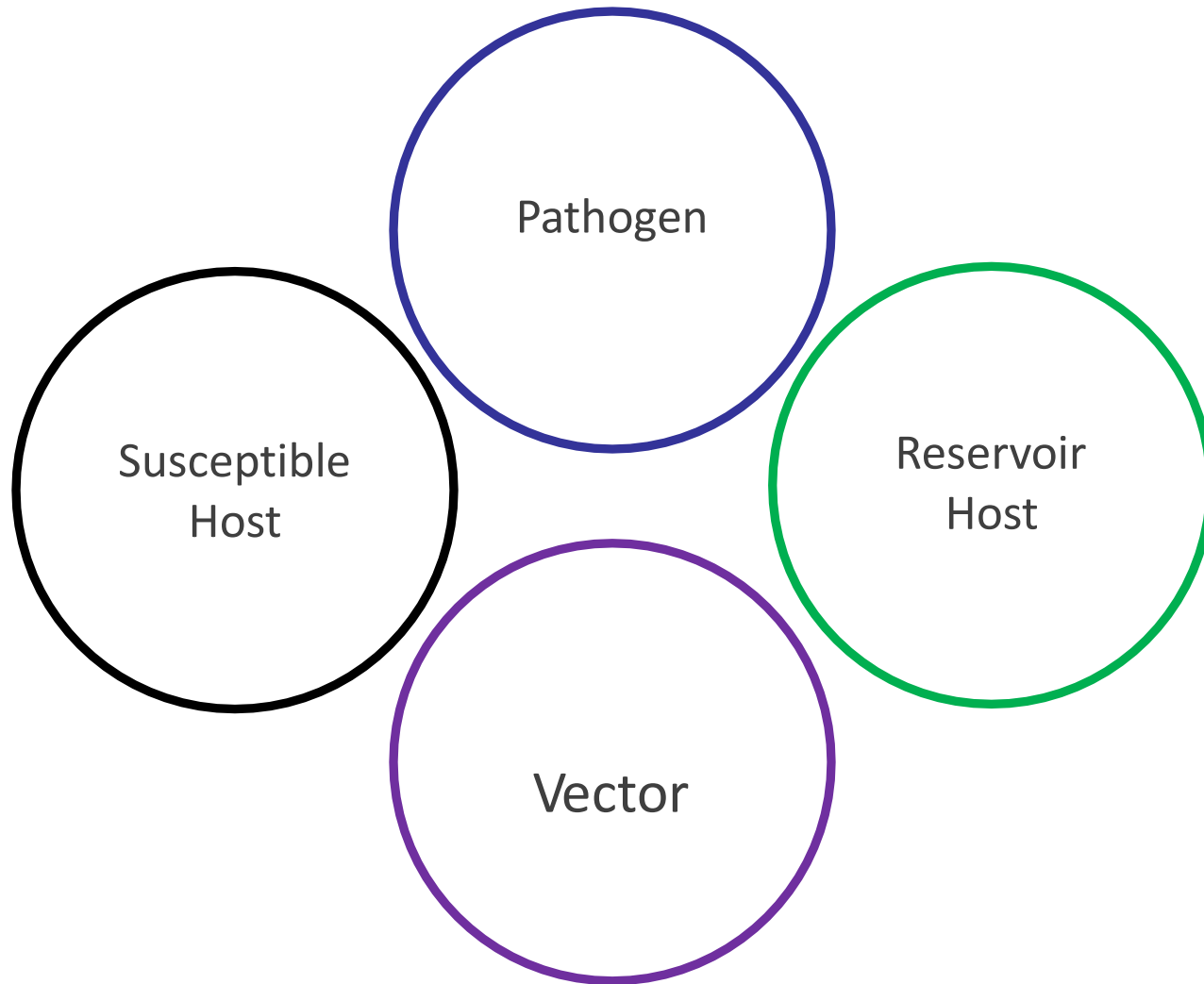
## ❑ Landscape (Extrinsic)

- Climate, rainfall, temp, humidity, elevation, habitat



Where can you break the cycle?

# Vector Disease Transmission



# The Nida of Disease

## Enzootic Cycle

*Sand fly  
vector*



*Mammalian  
Reservoir  
(home to the  
pathogen)*



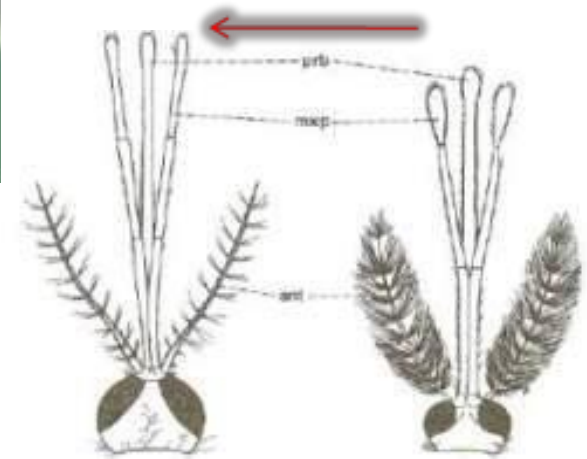
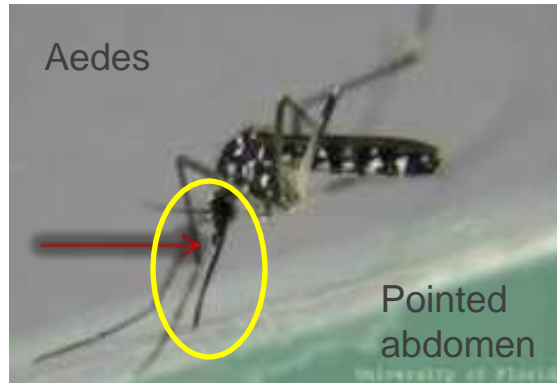
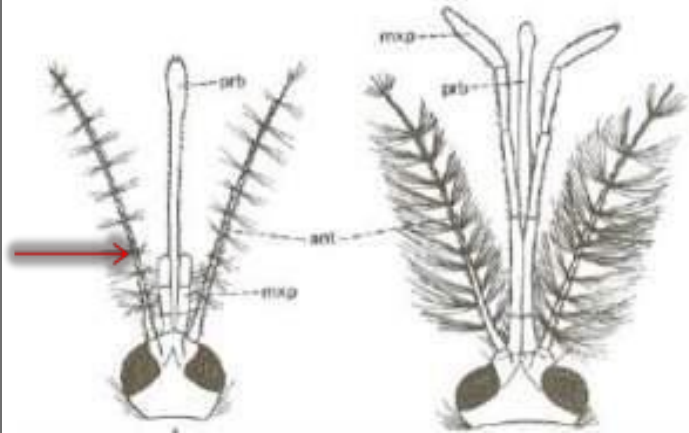
*Incidental Host*



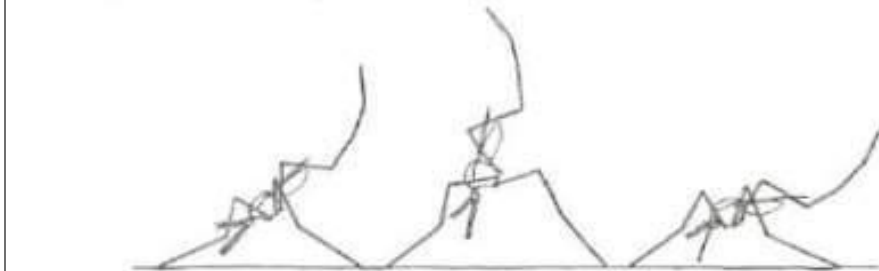
*Man and his  
Activities*

# Mosquitoes

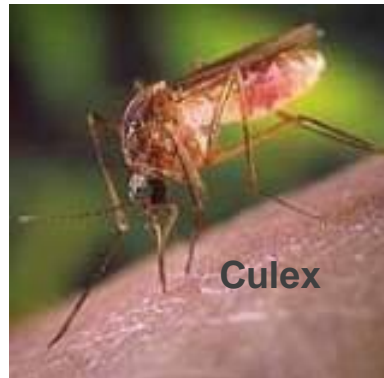
# Mosquito Comparison



Length of palps  
compared to  
proboscis



Resting  
and  
Feeding  
behavior



# Behavior & Habitat Comparison



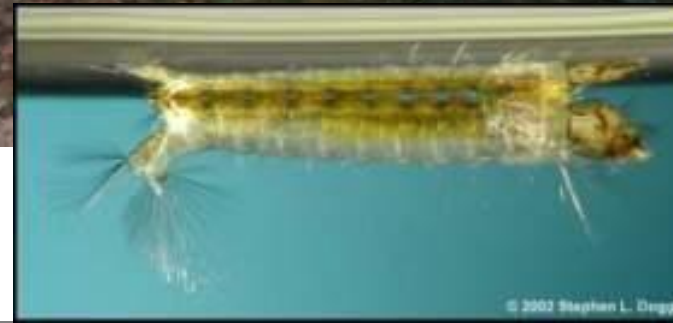
Aedes, Culex:  
Stagnant, dirty,  
temp pools, and  
opportunistic



Anophelines: typically  
cleaner, slowly flowing; in  
some places temp pools ok as  
long as not stagnant



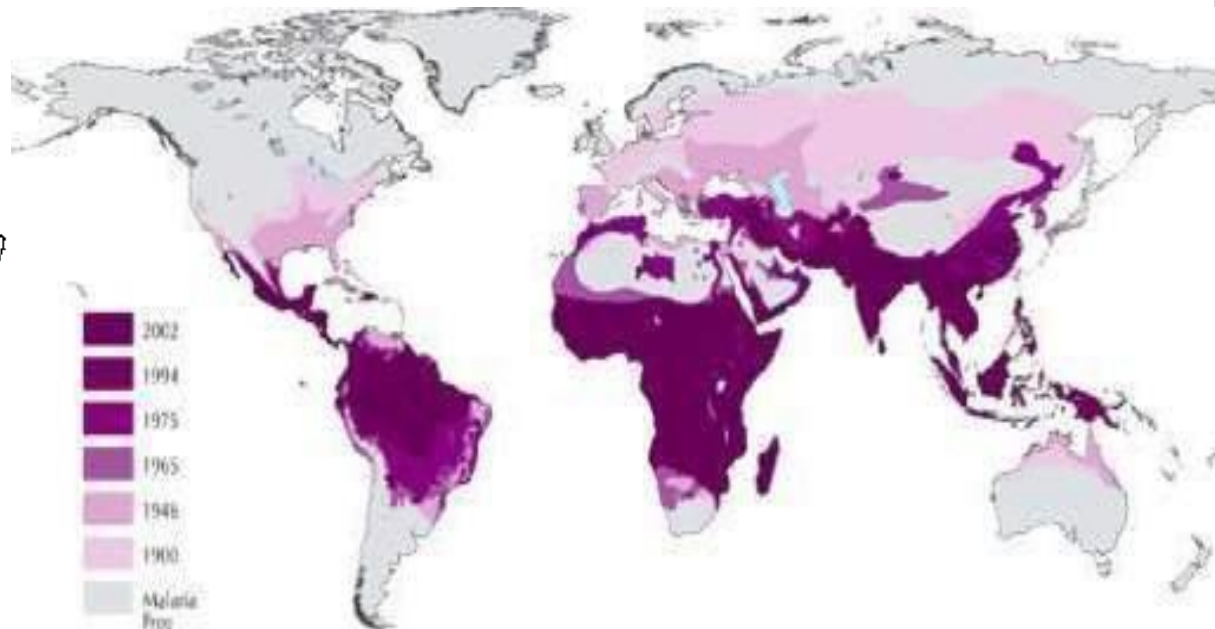
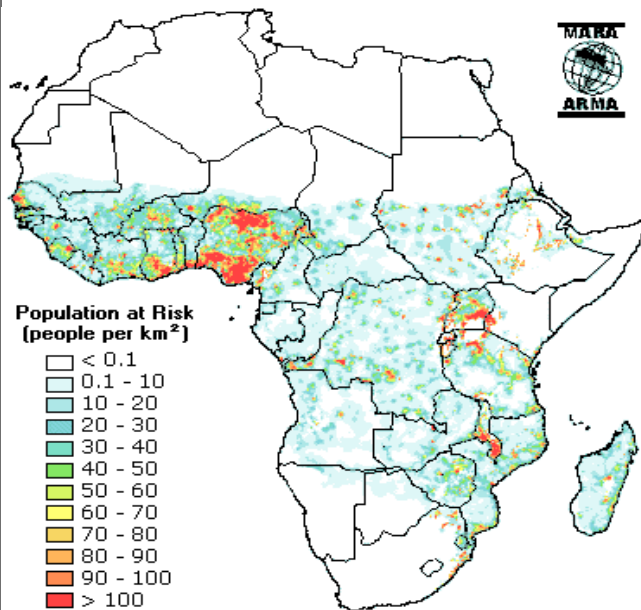
Aedes,  
Culex: body  
hangs down  
from the  
surface;  
uses  
breathing  
tube





# Malaria- Mosquitoes

- Risk varies geographically
  - Different species of *Anopheles* mosquitoes (varying competence)
- Entomological inoculation rate (EIR).
  - An estimate of exposure to infective mosquitoes
  - EIRs can exceed 1 infective bite per person per night



# Biology of Anopheles spp.

## Adult:

- Live 3 to 4 weeks although some can overwinter.
- Feeding occurs at night (dusk to dawn).
- Host preference varies by species.
- **Indoor vs. outdoor feeding.**





# Aedes Vectors



Ae. albopictus



Ae. aegypti

# Aedes Comparison



*Ae. aegypti*



*Ae. albopictus*

*Environment-*

Urban

Forest

*Breed/feed-*

Indoors(< 200m)

Outdoors

*Container type-*

Artificial

Natural and artificial

*Biting peak-*

Daytime

Dusk

*Host-*

Human

Human/Vertebrates

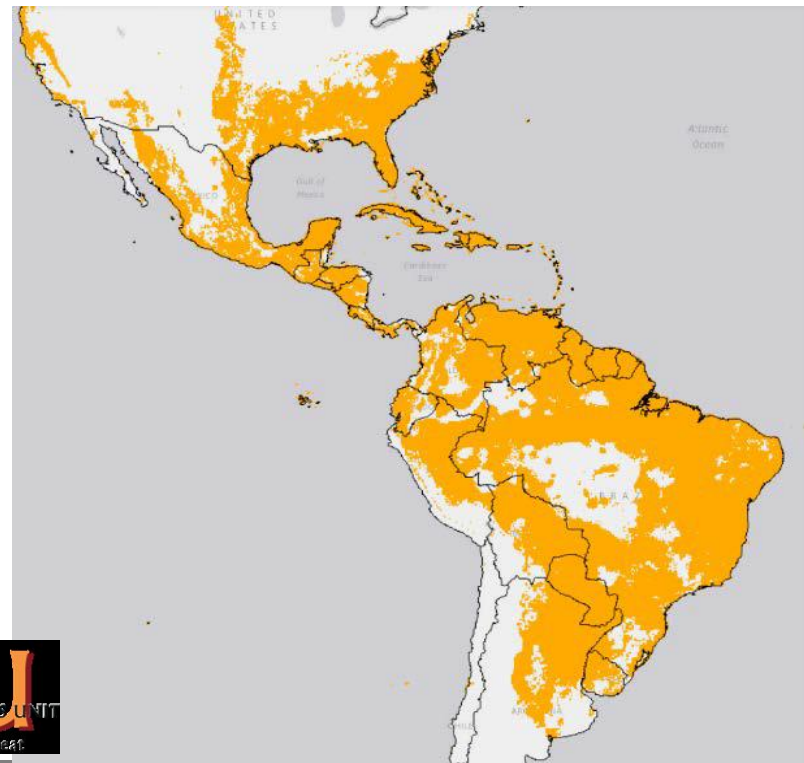
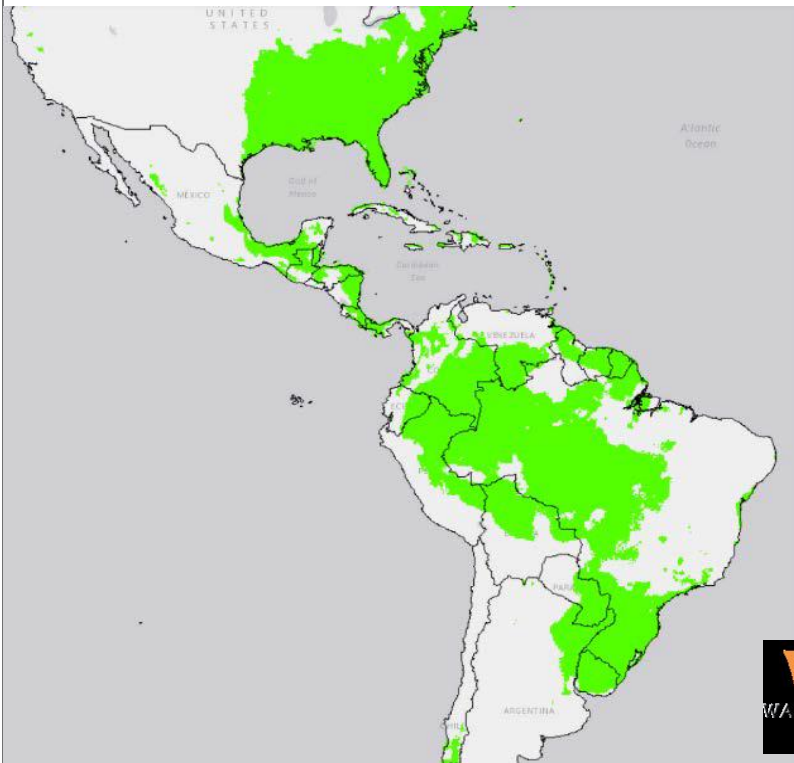
*Flight Range-*

< 200m

< 600m

# Zika Virus

- ABOUT 1 IN 5 PEOPLE BECOME ILL.
- SYMPTOMS ARE FEVER, RASH, JOINT PAIN, CONJUNCTIVITIS, MUSCLE PAIN, AND HEADACHE.
- THE INCUBATION PERIOD IS NOT KNOWN, BUT IS LIKELY TO BE A FEW DAYS TO A WEEK.
- THE ILLNESS IS USUALLY MILD WITH SYMPTOMS LASTING FOR SEVERAL DAYS TO A WEEK.
- PEOPLE USUALLY DON'T GET SICK ENOUGH TO GO TO THE HOSPITAL.



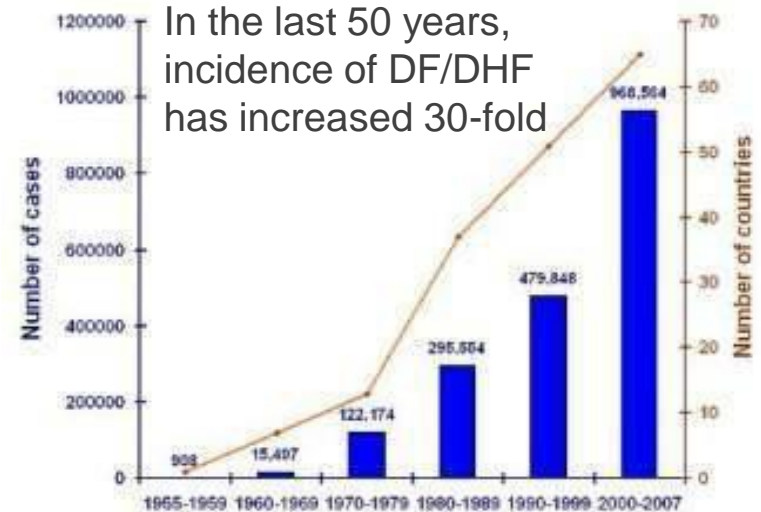
**WRBU**  
WALTER REED BIOSYSTEMATICS UNIT  
Know the vector, know the threat.

# Dengue

Laboratory-Confirmed DHF in the Americas  
Prior to 1981 vs. 1981 - 2003



Average annual number of DF/DHF cases reported to WHO & average annual number of countries reporting dengue



Emergence of DEN/DHF



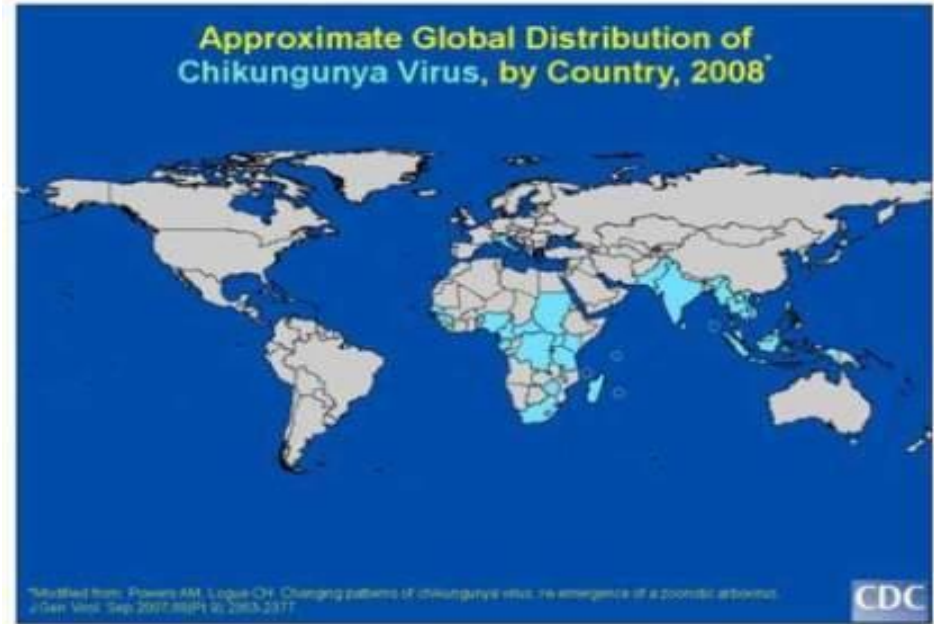
- Endemicity has increased from 9 countries to ~128 countries since the 1970s (*Brady, et al*)
- One recent estimate indicates **390 million** dengue infections per year (*Bhatt, et al*)
- The dengue transmission cycle occurs in the US
- No vaccine yet (3 are in phase II and III clinical trials)

- *Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, Moyes CL et.al. The global distribution and burden of dengue. Nature;496:504-507.)*
- *Brady OJ, Gething PW, Bhatt S, Messina JP, Brownstein JS, Hoen AG et al. Refining the global spatial limits of dengue virus transmission by evidence-based consensus. PLoS Negl Trop Dis. 2012;6:e1760. doi:10.1371/journal.pntd.0001760.)*



# Chikungunya Fever

- Mosquito-borne virus
- Like dengue, traditional vector is *Ae. aegypti* but *Ae. albopictus* is competent vector; equivalent eradication challenges
- Symptomology comparable to dengue
- Continuous outbreaks since 2005 in Europe, Asia & Africa, to include areas not previously endemic; over 200 cases in Italy in 2007
- Caribbean outbreak in 2014 had over 230,000 cases



Sep 2014- US imported CHIK-V cases reaches >1050; 45 states affected; eleven cases of secondary transmission in FL

# Filariasis

Vector depends on the geographic area

- Africa: *Anopheles*
- Americas: *Culex quinquefasciatus*
- Pacific and Asia: *Aedes* and *Mansonia*

**Biting behaviors matter!**



# Sand Flies

# Characteristics

- Small (2-3 mm)
- Brown (but appear white when illuminated)
- Wings held in erect V-shape (even dead)
- Nocturnal
- Do not hover
- Silent
- Painful bite for some

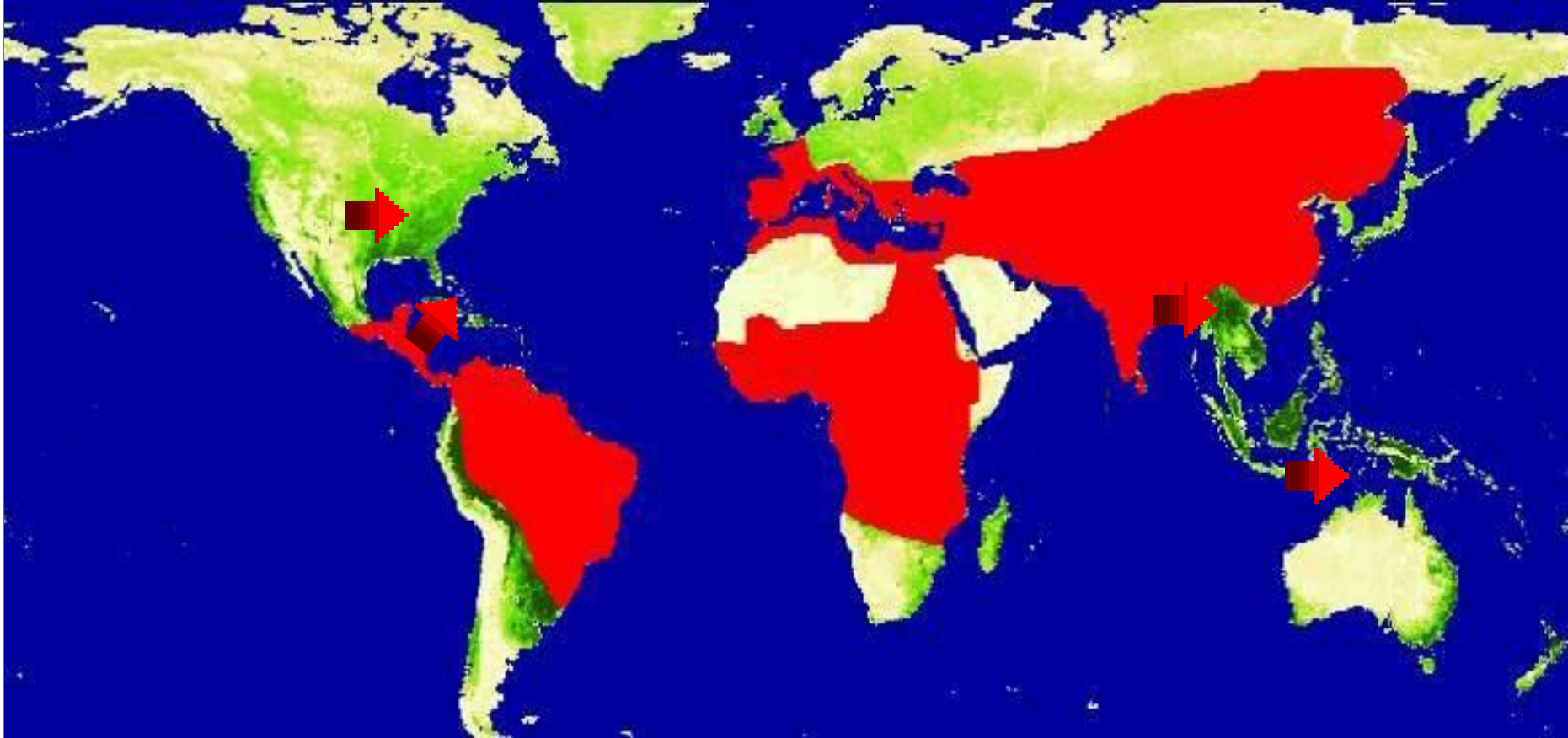




# Sand flies – vital requirements

- Larvae breed in soil (not aquatic)
- Only females take blood, from a variety of vertebrate species
- Rest during the day in dark, humid microhabitats
- Both sexes require sugar as an energy source

# Global distribution of the leishmaniases (but not the global distribution of sand flies)



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# Psychodidae:



Drain Fly – Damp habitats, plumose antennae,  
Larger, broader wings, more hair



Lutzomyia (New World)

*Sand Fly*

Phlebotomus (Old World)





# Variable Habitats: rain forest, desert, mountains, cities



# Ticks

# Tick Borne Diseases

- Lyme disease
- Ehrlichiosis
- Rocky Mountain Spotted fever
- Babesiosis
- Spotted fever group rickettsioses
- Tick borne encephalitis (TBE)
- Crimean Congo Hemorrhagic Fever (CCHF)

# African Tick Bite Fever

## African tick-bite fever (*Rickettsia africae*)

- An emerging infectious disease endemic in sub-Saharan Africa
- The most commonly encountered rickettsiosis in travel medicine
- *Amblyomma*, *Dermacentor*, *Rhipicephalus*



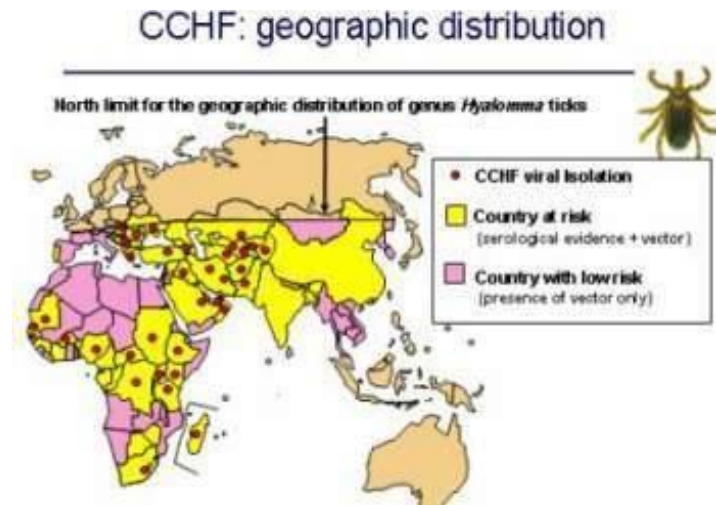
1. Ndip et al., 2011. Risk Factors for African Tick-Bite Fever in Rural Central Africa. *Am. J. Trop. Med. Hyg.*

2. Raoult et al., 2001. *Rickettsia africae*, a tick-borne pathogen in travelers to sub-Saharan Africa. *N Engl J Med*



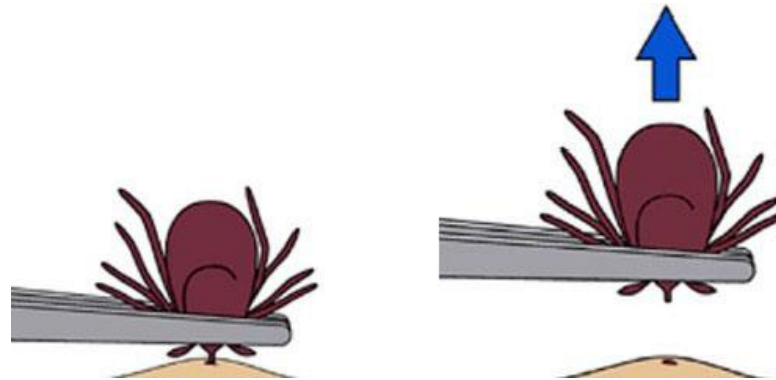
# Crimean Congo Hemorrhagic Fever

- **First US Soldier death from CCHF since WWII acquired in Afghanistan in Sep 09.**
- Tick-borne virus with a 30% mortality rate
- **Can also be transmitted by exposure to fresh infected blood (human or animal)**
- Endemic in many countries in Africa, Europe, Asia and the Mediterranean; since 2001 cases or outbreaks have been recorded in Kosovo, Albania, Iran, Pakistan, Georgia and South Africa
- **Most widely distributed HF in the world**
- **Austere conditions increase the likelihood of transmission; fewer “tick checks”, formal or informal**
- Intensive monitoring of blood volume and component required



# How to remove a tick

- Use fine-tipped tweezers to grasp the tick as close to the skin's surface as possible.
- Pull upward with steady, even pressure. Don't twist or jerk the tick; this can cause the mouth-parts to break off and remain in the skin. If this happens, remove the mouth-parts with tweezers. If you are unable to remove the mouth easily with clean tweezers, leave it alone and let the skin heal.
- After removing the tick, thoroughly clean the bite area and your hands with rubbing alcohol, an iodine scrub, or soap and water.
- Dispose of a live tick by submersing it in alcohol, placing it in a sealed bag/container, wrapping it tightly in tape, or flushing it down the toilet. Never crush a tick with your fingers.



Avoid folklore remedies such as "painting" the tick with nail polish or petroleum jelly, or using heat to make the tick detach from the skin. Your goal is to remove the tick as quickly as possible--not waiting for it to detach.

Centers for Disease Control and Prevention; June 1, 2015

# Sleeping Sickness





# African Trypanosomiasis- Tsetse Fly



Larvae are soil dwelling so control measures target adults



Glossinidae sp.

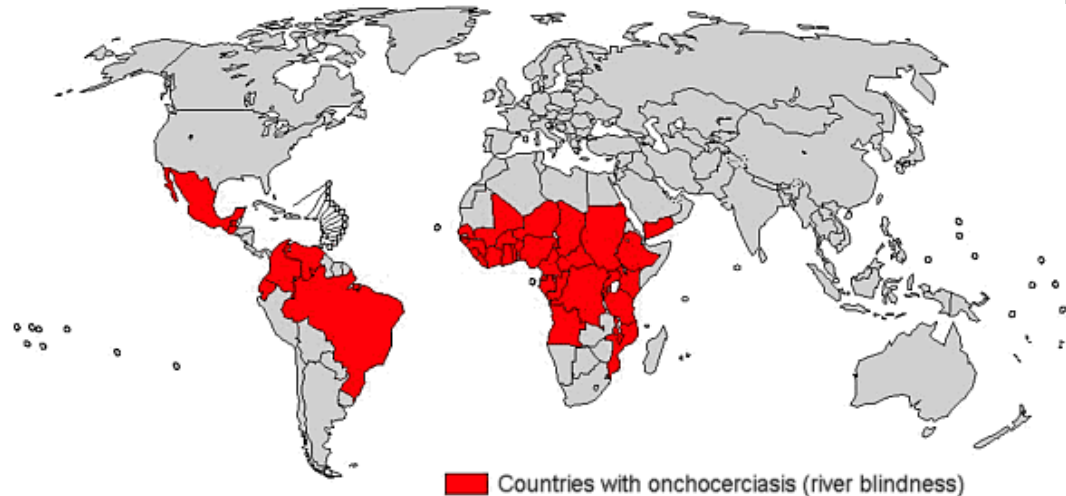


Distinct features: long proboscis, calyptrate antennae, ptilinal suture, the wings overlap completely when held over the abdomen, the discal medial (i.e. the middle) cell of the wing has a characteristic hatchet shape; and it has more bulk than the Muscidae flies.

# Onchocerciasis- Black Flies

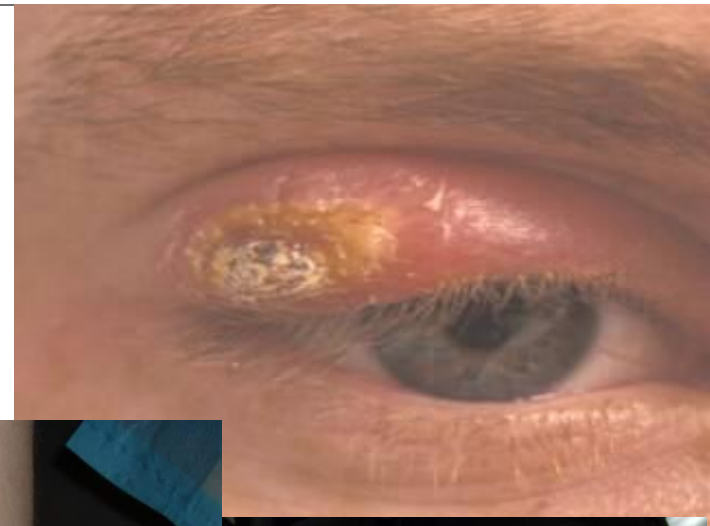


- *Simulium complex* breed in fast-flowing streams and rivers hence the commonly known name of “river blindness”
- Large flight range
- Larval stage is targeted by control programs
- Painful daytime bite; “pool feeders”, ideal for transmission of microfilarial into skin
- Thousands of eggs can be laid at one time, outbreaks can be ecologically linked



# Physical Threats





It's not just  
about  
disease...



# Direct Injuries

- Insects in eyes, ears and nose
- Biting to feed w/o disease transmission
- Myiasis
  - Humans as an incidental host for insects
  - Larva develop in an animal feeding on body fluids before emerging as an adult



# Bites and Stings

- Spiders, centipedes, scorpions, bees, wasps, etc... all inject venom when they bite or sting.
- Some envenomizations are only painful but some can cause death.
- Blister Beetles – excrete a chemical blistering substance that causes blisters.
- Uricating hairs – hairs from the arthropods that cause painful irritations on human skin.



**Scorpion**



**Wasp**



**Solifugae (Camel Spider)**



**Leafcutter**



**South African Wandering Spider**



**Honey Bee Swarm**



# Snakes

- Venomous vs. Non-venomous
  - Unless you are an expert you don't know and must assume all are poisonous
- Viperids (Vipers)
  - True Vipers – Puff adders, Saw-scaled viper
  - Pit Vipers – Rattlesnakes, copperheads
- Colubrids
  - Most are harmless but others have potent venom (Boomslang)
- Elapids
  - Sea snakes, taipans, coral snakes, kraits, death adders, mambas, king cobra and cobra's





Horned Viper



Milk Snake vs Coral Snake



Rattlesnakes



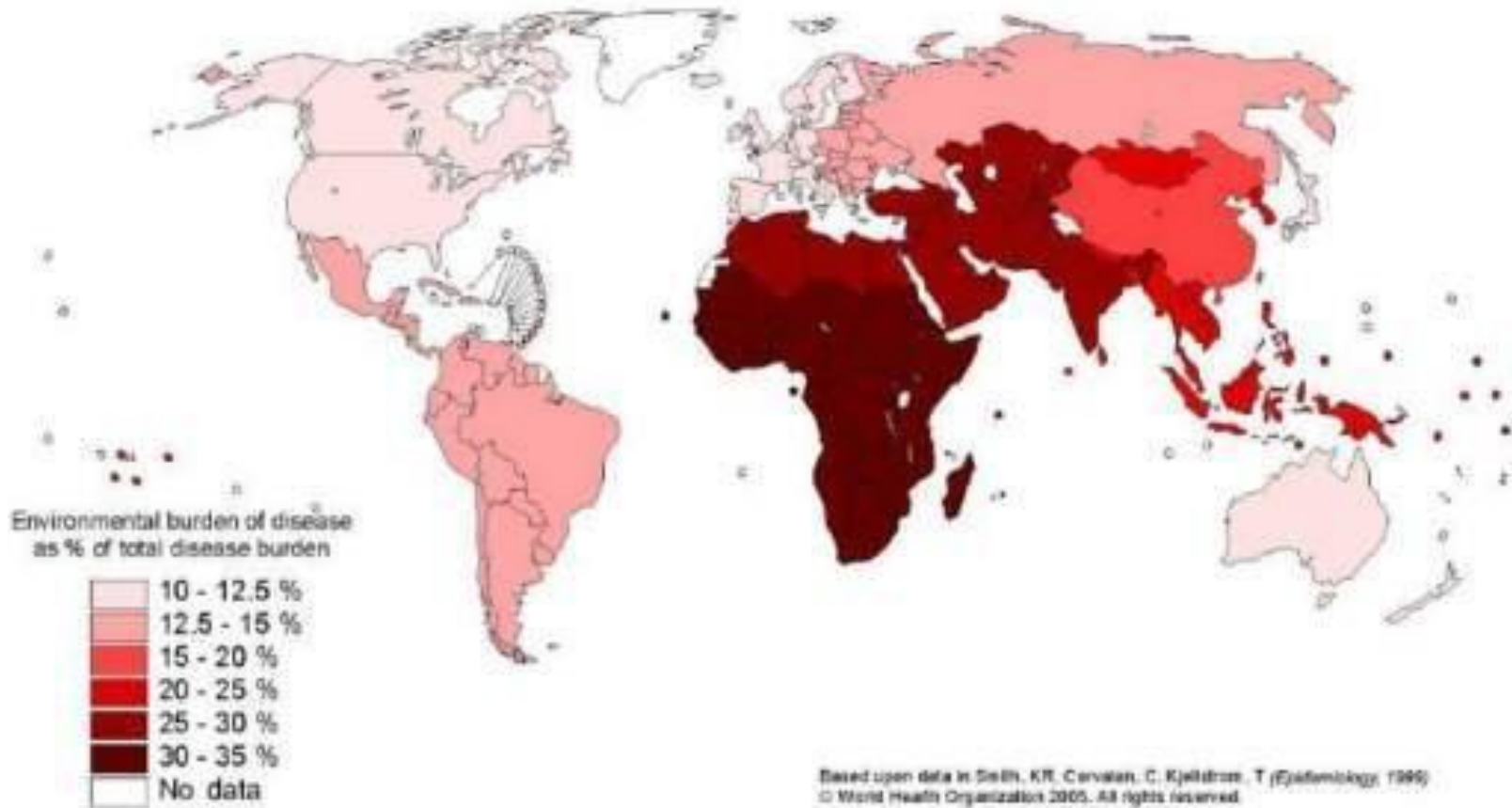
Cobra



# Understanding the threat

What are the threats in my AO?

Depends on **where** you are and **when** you are there.



# Determining the Risk

1. What diseases are known to be present?
2. Will the mission put personnel into close contact with vectors?
  - VECTOR BEHAVIOR
    - *Anopheles* mosquitoes are nighttime biters
    - *Aedes* mosquitoes are daytime biters
    - Sandflies typically fly close to the ground
  - VECTOR HABITAT...Will personnel operate in areas with vectors?
  - BILLETING...in buildings with doors and screened windows?
3. Will conditions support disease transmission?
  - SEASONALITY
  - RECENT WEATHER
  - DENSITY OF VECTOR
  - INFECTION RATE



# Where will you be staying?



Tents?

Huts?

Environmental  
Units?



# HELP IN IDENTIFYING PRIORITY THREATS

- **Entomological Operational Risk Assessments (EORA)**

- Provide risk estimates for vector-borne and zoonotic diseases in the country of concern.
- These estimates, prepared by USAPHC.
- EORAs available for >30 countries.

- Infectious Disease Risk Assessment (IDRA)
  - NCMi
  - Web-based and CD (MEDIC)
  - Classified and unclassified medical intelligence/information
- Disease Vector Ecology Profiles (DVEP)  
<http://www.afpmb.org/content/disease-vector-ecology-profiles>
  - Geosentinel
  - ProMed

# REGIONAL RISK

## DVEPS

- Provide risk estimates for vector-borne and zoonotic diseases in the regions of concern
- Prepared by AFPMB



Office of the Deputy Under Secretary of Defense for Installations & Environment



## Regional Disease Vector Ecology Profile

### South Central Asia



Defense Pest Management Information Analysis Center  
Armed Forces Pest Management Board  
Forest Glen Section  
Walter Reed Army Medical Center  
Washington, DC 20307-5001

Homepage: <http://www.afpmb.org>

September 2001



The Walter Reed Biosystematics Unit (WRBU) is a unique national resource. Its mission is to conduct systematics research on medically important arthropods and to maintain the U.S. mosquito collection. The WRBU is just one part of the U.S. Government's entomological research system, which includes the U.S. Department of Agriculture (USDA) and the Smithsonian Institution (SI). Historically, mosquito identification was managed by USDA and the SI, but in 1972 this responsibility was transferred from USDA to the U.S. Army for research on medically important arthropods. Located at the Museum Support Center of the Smithsonian Institution in Suitland, Maryland, the WRBU's physical space is provided by the Smithsonian Institution in return for curation of the collection and specimen identification... [\(more\)](#)

## What's New?

Mosquito Classification 2010 

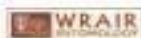
Discussion Forum

New mosquito identification keys

See new WRBU staff publications



MosquitoMap.org  
SandflyMap.org  
TickMap.org



## Vector Identification Resources

to medically important arthropods and WRBU's Vector Identification System

### Mosquito Resources



Culicidae Catalog  
[www.mosquitocatalog.org](http://www.mosquitocatalog.org)



Mosquito Genera



Mosquito Literature



Medically Important



Mosquito Species  
Identification Keys

### Other Vectors



Sand Flies



Ticks



Scorpions



Fleas

<http://wrbu.si.edu/>



# VectorMap



- Comprised of MosquitoMap, SandflyMap and TickMap
- Geospatially referenced clearinghouses for arthropod disease vector species collection records and distribution models
- Users can pan and zoom to anywhere in the world to view the locations of:
  - past vector collections and
  - the results of modeling that predicts the geographic extent of individual species

<http://mosquitomap.nhm.ku.edu/vectormap/>

VectorMap is new and still in the test phase.  
Requires you to download Silver Light freeware from Microsoft.

# RESOURCES

- Command PM assets
- Regional Public Health Command (PHC), Ento Div <http://chppm-www.apgea.army.mil/ento/default.htm>
- AFPMB [www.afpmb.org](http://www.afpmb.org)
  - Living Hazards Data Base
  - Disease Vector Ecology Profiles (DVEPS)
- National Center for Medical Intelligence (MEDIC CD)
- WRAIR Entomology Division
  - Walter Reed Biosystematics Unit (WRBU)  
<http://wrbu.si.edu>  
<http://mosquitomap.nhm.ku.edu/vectormap/>

# PERSONAL PROTECTION

# WHAT CAN YOU DO TO MINIMIZE RISK?

- Find out what the **priority risks** are in your area before you deploy
- Understand the **vectors** so you can **avoid** them
- Implement Personal Protective Measures
  - Use **repellents**
  - Sleep under **insecticide treated netting**
  - Wear **permethrin treated** uniforms
  - Take **malaria chemo** if directed

# DEET

- DEET is the active ingredient in many insect repellent products.
- EPA reviews of DEET in 1998 and 2014 did not identify any risks of concern for human health.
- DEET products come in many formulations including: lotions, sprays, liquids, impregnated materials (towelettes).



# Picaridin

- Picaridin is a colorless, nearly odorless liquid active ingredient that is recommended by the AFPMB as an alternative to DEET.
- Lab and field studies of products containing picaridin (10-20%) indicate good protection.
- 7.5% products are not as effective.



Natrapel, 20%, 3.5-oz. Pump Spray  
NSN 6840-01-619-4795



# AFPMB Approved Repellents

- **DEET**

- Ultrathon by 3M (NSN 6840-01-284-3982)
- Ultra by Sawyer (NSN 6840-01-584-8393)
- Cutter Pump Spray (NSN 6840-01-584-8598)

- **Picaridin**

- Natrapel pump spray (NSN 6840-01-619-4795)

# Treated Uniforms



- PERMETHRIN IS THE REPELLENT EPA REGISTERED TO TREAT CLOTHING
- THE MARINES AND ARMY ARE CURRENTLY ISSUING FACTORY TREATED UNIFORMS
- PERMETHRIN TREATED CLOTHING IS SOLD COMMERCIALY

# Myth Busters



- There is NO evidence that eating garlic or taking vitamin B tablets reduces mosquito bites.
- Citronella is an extremely WEAK area repellent, and it's only the oil that comes from crushing the leaves
- Drinking alcohol may increase your attractiveness to mosquitoes.
- Color of clothing is a weak defense, but studies have shown that some of the 174 mosquito species in the United States are more attracted to dark clothing (AMCA 2014).



# Myth Busters

- Sonic and electronic devices do NOT work.



# Area Repellents

- Some mosquito control devices use repellents to protect a small outdoor area like a patio.
- No products are approved by the EPA **for indoors**.
- There are no area repellents **currently** approved for use by the DoD but there is a DHP funded phase II SBIR , so IT'S CLOSE.



# Questions?